Leaving Certificate Examinations 2005

Chemistry – Higher Level

Marking Scheme
Introduction

In considering the marking scheme the following should be noted.

1. In many cases only key phrases are given which contain the information and ideas that must appear in the candidate’s answer in order to merit the assigned marks.

2. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.

3. The detail required in any answer is determined by the context and the manner in which the question is asked, and by the number of marks assigned to the answer in the examination paper and, in any instance, therefore, may vary from year to year.

4. The bold text indicates the essential points required in the candidate’s answer. A double solidus (//) separates points for which separate marks are allocated in a part of the question. Words, expressions or statements separated by a solidus (/) are alternatives which are equally acceptable for a particular point. A word or phrase in bold, given in brackets, is an acceptable alternative to the preceding word or phrase. Note, however, that words, expressions or phrases must be correctly used in context and not contradicted, and where there is evidence of incorrect use or contradiction, the marks may not be awarded.

5. In general, names and formulas of elements and compounds are equally acceptable except in cases where either the name or the formula is specifically asked for in the question. However, in some cases where the name is asked for, the formula may be accepted as an alternative.

6. There is a deduction of one mark for each arithmetical slip made by a candidate in a calculation.
Outline Marking Scheme

Section A [At least two questions must be answered from this section]

1. (a) Why 5 or 3; (b) Why conc. 6; (c) Describe 2 x 3, 3; (d) Describe 3 x 3; (e) Indicator 3, When 3, Colours 3; (f) Calculate 6; (g) Calculate (6).

2. (a) Why 5; (b) Two features 4 x 3; (c) Describe 2 x 3, Account 3; (d) Test 2 x 3, Observe 2 x 3; (e) Mass 12.

3. (a) Equation 5; (b) Draw 4 x 3; (c) Which 3, Reason 3; (d) Graph 3, 6, 3; (e) Use (i) 3, (ii) 6; (f) What 2 x 3.

Section B

Eight items to be answered. Six marks are allocated to each item and one additional mark is added to each of the first two items for which the highest marks are awarded.

4. (a) 2 x 3; (b) 2 x 3; (c) 6; (d) 2 x 3; (e) 2 x 3; (f) 2 x 3; (g) 2 x 3; (h) 6; (i) 2 x 3; (j) 2 x 3; (k) A 2 x 3, (k) B 6.

5. (a) Isotopes 5, Name 3, Example 6, Use 3; (b) Define 2 x 3, Describe (i) across 3, Account 2 x 3 or 6, Describe (ii) down 3, Account 3; (c) Define 2 x 3, Distinguish 2 x 3.

6. (a) (i) Name 2 x 4, (ii) State 2 x 3, (iii) Why 3, (iv) Identify 3; (b) 3 x (2 x 3), (c) 12.

7. (a) Name 5; (b) Classify 4 x 3; (c) Describe 4 x 3, How 2 x 3; (c) State 2 x 6 + 3.

8. (a) Define (i) 4, (ii) 4; (b) Identify 2 x 3; (c) Calculate 12; (d) BOD 2 x 3; (e) Describe: primary 2 x 3, secondary 2 x 3, What 2 x 3.

9. (a) State 2, 3; (b) (i) Describe 4 x 3, (ii) Describe 3 x 3; (c) (i) Write 6, (ii) Calc. 18.

10. (a) (i) Calc. 8; (ii) Calc. 5; (iii) Calc. 6; (iv) Calc. 6. (b) (i) Identify 4, State 3; (ii) Equation 6; (iii) Would 3, Explain 3; (iv) How 3, React 3. (c) State 4 + 2 x 3, Describe 5 x 3.

11. (a) (i) Define 4; (ii) What 3, Explain 2 x 3; (iii) Electrode 3, Which 3, Write 2 x 3. (b) (i) Define 7; (ii) State 2 x 3; (iii) How much 12. (c) A (i) What 4 x 3; (ii) Name 3; (iii) Describe 9; (iv) Give 2 x 3. (c) B (i) Account 4 + 3; (ii) What 3, State 2 x 3; (iii) Describe 3 x 3.
SECTION A

At least two questions must be answered from this section.

QUESTION 1

(a) WHY: so that oxygen content doesn’t increase (change) due to photosynthesis / so that oxygen content doesn’t decrease (change) due to respiration / so that oxygen content doesn’t change (increase/decrease) due to activity of organisms in the water

[the oxygen content may change over time / due to respiration of micro-organisms / due to photosynthesis of plant material Any one of these merits only (3)]

[Allow 3 marks for “accuracy”. Also allow only (3) for “decrease due to photosynthesis” or “increase due to respiration” as a contradiction is present.]

Note: do not award marks for attempts like “may absorb oxygen from the air” or “may become contaminated from the air (atmosphere)” – the bottle is stoppered.

(b) WHY CONC.: to minimise the amount of the water sample that is displaced / minimise the change in the oxygen dissolved in the sample / so that a small volume (amount) supplies excess

[Allow 3 marks for “to prevent water being displaced”/ “accuracy”/ “excess reagents” / “solutions to sink to bottom”/ “oxygen content of solutions added may be different”]

(c) DESCRIBE: remove a few cm$^3$ of river water from the bottle / addition made so that water overflows from the bottle // make additions under the level of the water // using a dropper (pipette, syringe) //
do not bubble air (oxygen) into the water in the process //

WHAT: do not trap air (oxygen) bubbles

any two: (2 × 3)

(d) DESCRIBE: rinse with water followed by iodine // fill pipette using a pipette filler to above the mark (graduation line) // adjust to have bottom of meniscus on mark / read at eye level (vertically) // remove droplets adhering to outside //
drain under gravity into titration flask // touch tip of pipette against side of flask to add droplet adhering to outside tip //
do not blow out drop inside pipette

any three: (3 × 3)

(e) INDICATOR: starch

WHEN: when the solution is straw-yellow (light yellow, straw-coloured) / becomes pale

COLOURS: blue-black (black, blue, indigo, navy) to colourless (do not accept “clear”)

(f) CALCULATE: 0.0006 / 6 x $10^{-4}$ mol l$^{-1}$

\[
\frac{50 \times X}{1} = \frac{6.0 \times 0.01}{2}
\]

\[X = \frac{0.0006}{6 \times 10^{-4}}\]

(g) CALCULATE: 9.6 p.p.m.

\[
0.0006 \div 2 = 0.0003
\]
\[
0.0003 \times 32 \times 1000 = 9.6
\]
QUESTION 2

(a) WHY: volatile product / ethanal has low b.p. / ethanal boils at about 21 °C (room temp) (5)

(b) TWO FEATURES: first feature (3) explanation (3); second feature (3) explanation (3)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess ethanol/dichromate</td>
<td>Stops at ethanal/doesn't go to ethanoic acid</td>
</tr>
<tr>
<td>Immediate distillation</td>
<td>Prevents further (over) oxidation</td>
</tr>
<tr>
<td>Dichromate in funnel</td>
<td>Small amount of oxidising agent in flask</td>
</tr>
</tbody>
</table>

(c) DESCRIBE: orange solution added to colourless liquid // becomes green (2 × 3)

ACCOUNT: Cr(VI) / Cr$_2$O$_7^{2-}$ is reduced to Cr(III) / Cr$^{3+}$ (3)

(d) TEST: mix (add) equal amounts of Fehling's 1 (Fehling's A / copper sulfate/CuSO$_4$ solution) and Fehling's 2 (Fehling's B, alkaline/sodium hydroxide/NaOH solution with Rochelle salt/potassium sodium tartrate/potassium sodium 2,3-dihydroxybutanedioate) (3)

Add ethanal and warm / heat / put test tube in hot (boiling) water (3)

OBSERVE: brick-red (accept orange/brown) precipitate produced (3)

(e) MASS: 2.97 g [Accept 2.948 – 3.000 g] (12)

\[
\begin{align*}
8.94 \text{ g sodium dichromate} & \rightarrow 0.03 \text{ mol} \\
0.03 \text{ mol dichromate} & \equiv 0.09 \text{ mol ethanal} \\
0.09 \text{ mol ethanal} & \rightarrow 3.96 \text{ g ethanal} \\
75 \% \text{ yield} & = \frac{3.96 \times 75}{100} = 2.97 \text{ g}
\end{align*}
\]

OR

\[
\begin{align*}
75 \% \text{ yield} & = \frac{0.09 \times 75}{100} = 0.0675 / 0.067 / 0.068 \text{ mol} \\
0.0675 \text{ mol} & \rightarrow 2.97 \text{ g}
\end{align*}
\]

[*addition must be shown for error to be treated as slip*]
QUESTION 3

(a) EQUATION: \[ 2\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + 2\text{H}_2\text{O} \quad \text{or} \quad \text{H}_2\text{O}_2 \rightarrow \frac{1}{2}\text{O}_2 + \text{H}_2\text{O} \] [Allow 3 marks if all formulas are correct]

(b) DRAW: reaction vessel with hydrogen peroxide and catalyst

method of ensuring correct start time (stated or shown) e.g. catalyst in neck of horizontal flask; bring flask to vertical and start clock / catalyst in small test tube in flask; mix and start clock / add catalyst, stopper, and start clock

[N.B. Descriptions of starting reaction and clock at same time must be clear. Adding peroxide from funnel is not acceptable as start time is not exact and volume collected is incorrect due to displacement of air.]

delivery tube connected to gas collection system (syringe or over water)

clear method of measuring (e.g. syringe with calibrations or inverted graduated cylinder)

[At least one label required]

(c) WHICH: finely / former / first option

REASON: greater activity / greater surface area available

(d) GRAPH: labelled and scaled axes [Accept “time” or “minutes”; “volume” or “cm$^3$”.]

points plotted correctly
[Allow 3 marks if six or more points plotted correctly; assume (0, 0) is plotted correctly]

curve drawn [has to be drawn to (0, 0)]

Note: the (6) for points plotted correctly not given if graph paper not used.

(e) USE:

(i): \[ 26.5 – 28.5 \text{ cm}^3 \] (3)

(ii): \[ 6.0 – 8.0 \text{ cm}^3 \text{ min}^{-1} \] [Accept in cm$^3$ s$^{-1}$] (6)

[For answers outside this range, (3) may be given for a good tangent drawn at the correct point on the graph]

(f) WHAT: rise less steep / levels off later

maximum volume 20 cm$^3$ / half the final volume / less oxygen produced

Note: changes may be shown on the candidate’s graph paper or through a suitable sketch.
SECTION B

QUESTION 4

Eight items to be answered. Six marks to be allocated to each item and one additional mark to be added to each of the first two items for which the highest marks are awarded.

(a) relative (measure of) attraction / number expressing (giving) attraction
for shared electrons / for electrons in a covalent bond

(b) linear / straight
bent / angular / “v”-shaped
(both available from diagrams, including shape diagrams using correct examples. No marks for “planar”. Cancelling does not apply for “planar” but does for descriptors like “triangular”.)

(c) Balmer (Accept phonetically similar efforts starting with B like “Bahlmer”, “Bahmer”, “Bamer” but not efforts like “Balman”, “Balmyn” or “Palmer”.)

(d) he grouped elements of similar properties
in groups of three / triads / description of triad

(e) atomic orbitals are three dimensional spaces about the nucleus of an atom where there is a high probability of finding an electron / region in which electron is likely to be found
an atomic sub-level is a sub-division of a main energy level consisting of one or more orbitals of the same energy / discrete energy values available in main level (shell)

(f) add concentrated solution of iron(II) sulfate (FeSO₄) followed by concentrated sulphuric acid (H₂SO₄) down the side of the test tube.
a brown ring develops at the junction of the two solutions

(g) ethylbenzene // dimethyl benzene (numbers not needed) / xylene

[Three correctly-placed double bonds in ring acceptable]

(h) CuCl₂

<table>
<thead>
<tr>
<th>Cu</th>
<th>Cl</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.175</td>
<td>63.5</td>
</tr>
<tr>
<td>6.725</td>
<td>35.5</td>
</tr>
<tr>
<td>0.05</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Ratio Cu : Cl = 0.05 : 0.1 = 1 : 2

(i) C₂H₅OH + Na → C₂H₅ONa + ½H₂ / 2C₂H₅OH + 2Na → 2C₂H₅ONa + H₂

[Allow 3 marks for correct formula for the organic product]

(j) C₂H₅OH + Na → C₂H₅ONa + ½H₂ / 2C₂H₅OH + 2Na → 2C₂H₅ONa + H₂

FORM: (3) BAL: (3)

(k) A: Cl⁺ + O₃ → ClO⁺ + O₂ / ClO⁺ + O⁺ → O₂ + Cl⁺ / ClO⁺ + O₃ → Cl⁺ + 2O₂

B: oxidised (corroded, loses electrons, forms pos. ions) more easily than protected metal / higher in electrochemical series than protected metal / forms cell in which protected metal is the cathode [Allow 3 marks for “more reactive”]
QUESTION 5

(a) ISOTOPES: atoms of same element (same atomic number, same Z, same number of protons) with different mass numbers (different A, different number of neutrons) (5)

NAME: Becquerel (3)

GIVE: Example (mass number essential) (6)

Use

Deuterium, H-2; (nuclear fusion); carbon-13 (tracers in biosynthesis); carbon-14 (dating of ancient remains); caesium-135 (measurement of second); cobalt-60 (radiotherapy, cancer treatment, sterilisation); americium-241 (smoke alarms); phosphorus-32 (plant nutrient tracer, medical e.g. bone scans, radiotherapy); iodine-125 (medical tracer); caesium-137 (radiotherapy); oxygen-18 (reaction mechanisms); technetium-99 (medical tracer); uranium-235/uranium-238 (weapons, power); etc., [Must be matched. Note: mass number essential]

(b) DEFINE: half internuclear distance / half the distance between the centres in a single homonuclear bond / of singly-bonded atoms of the same element (3)

DESCRIBE (i) ACROSS: decrease in atomic radius (3)

ACCOUNT: increase in nuclear charge constant screening effect (of inner shells) / same no. of (inner) shells or increase in effective nuclear charge for 6 marks [The marks for ACCOUNT cannot be awarded if the answer to ACROSS is incorrect.]

DESCRIBE (ii) DOWN: increase in number of filled shells (3)

ACCOUNT: [The marks for ACCOUNT cannot be awarded if the answer to DOWN is incorrect.]

(c) DEFINE: involving the sharing of one or more pair(s) of electrons (3)

DISTINGUISH: sigma – “end-on” ("head-on") overlap of orbitals / no nodal line (3)

pi – “side-on” ("sideways", "lateral") overlap of p-orbitals or d- or f- orbitals (3)

[Both can be got from diagrams. However, if the marks are to be awarded on the basis of diagrams, orbitals must be clearly labelled so that, for the \( \pi \) bond, overlapping “figures of 8” must be labelled as \( p \) orbitals, or else \( p \) orbitals must be specified in the accompanying text, and, similarly, the word “orbitals” must be used in connection with the \( \sigma \) bond, either as a label on the diagram, or in the accompanying text.]
QUESTION 6

(a) (i) NAME: 2,2,4-trimethylpentane (isooctane) // heptane (n-heptane) (2 x 4)

(ii) STATE: short chain length / branching / ring (cyclic) / aromatic ANY TWO: (2 x 3)

(iii) WHY: catalyst poison / destroys catalytic converter (3)

(iv) IDENTIFY: oxygenate / alcohol / methanol / ethanol / ether (alkoxyalkane) / methyl-ter-butyl ether (MTBE, 2-methoxy-2-methylpropane) (3)

(b) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 / \text{CH}_3(\text{CH}_2)_3\text{CH}_3 \) (3) pentane (3)

\( \text{(CH}_3)_2\text{CHCH}_2\text{CH}_3 / \text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)_2 \) (3) 2-methylbutane (3)

\( \text{(CH}_3)_2\text{C} / (\text{CH}_3)_2\text{CCH}_3 / (\text{CH}_3)_2\text{C}(\text{CH}_3)_2 \) (3) 2,2-dimethylpropane (3)

[Matching of names and formulae are required. In expanded structures, bonds without Hs are acceptable. Numbers are not required for the methyl branches but, if incorrect numbers are offered (e.g. 1,2-dimethylpropane), then no marks should be awarded.]

(c) \(-3271 \text{ kJ mol}^{-1}\) (12)

\[
\begin{align*}
\text{C} + \text{O}_2 & \rightarrow \text{CO}_2 \quad \Delta H = -394 \text{ kJ mol}^{-1} ; \\
6\text{C} + 3\text{H}_2 & \rightarrow \text{C}_6\text{H}_6 \quad \Delta H = -49 \text{ kJ mol}^{-1}
\end{align*}
\]

\[
\begin{align*}
2\text{C}_6\text{H}_6 & \rightarrow 12\text{C} + 6\text{H}_2 \quad -98 \text{ kJ} (3) \\
12\text{C} + 12\text{O}_2 & \rightarrow 12\text{CO}_2 \quad -4728 \text{ kJ} (3) \\
6\text{H}_2 + 3\text{O}_2 & \rightarrow 6\text{H}_2\text{O} \quad -1716 \text{ kJ} (3) \\
2\text{C}_6\text{H}_6 + 15\text{O}_2 & \rightarrow 12\text{CO}_2 + 6\text{H}_2\text{O} \quad -6542 \text{ kJ} \\
\text{C}_6\text{H}_6 + 7\frac{1}{2}\text{O}_2 & \rightarrow 6\text{CO}_2 + 3\text{H}_2\text{O} \quad -3271 \text{ kJ} (3)
\end{align*}
\]

\(\Delta H = \Sigma \Delta H_{f\text{(products)}} - \Sigma \Delta H_{f\text{(reactants)}}\)

\[
\begin{align*}
\Delta H &= 12 \times -394/ -4728 \text{ (3)} + 6 \times -286/ -1716 \text{ (3)} - \{2 \times 49/98 \text{ (3)} + 0\} \\
\text{OR} \quad 12 \times -394/ -4728 \text{ (3)} + 6 \times -286/ -1716 \text{ (3)} - 2 \times 49/98 \text{ (3)} - 0 \\
&= -6542 \Rightarrow \Delta H_c = -3271 \text{ (3)}
\end{align*}
\]

OR

\[
\begin{align*}
\Delta H &= 6 \times -394/ -2364 \text{ (3)} + 3 \times -286/ -858 \text{ (3)} - \{49 \text{ (3)} + 0\} \\
\text{OR} \quad 6 \times -394/ -2364 \text{ (3)} + 3 \times -286/ -858 \text{ (3)} - 49 \text{ (3)} - 0 \\
&= \Delta H_c = -3271 \text{ (3)}
\end{align*}
\]

[Allow 3 marks only for +3271 kJ mol\(^{-1}\) ]
QUESTION 7

(a) NAME: chloroethane / ethyl chloride [Accept with number e.g. 1-chloroethane] (5)

(b) CLASSIFY:

W  – elimination
X  – addition
Y  – addition
Z  – substitution

(4 × 3)

Note: If the letters W, X, Y and Z are not used, the marks may be allocated based on the order of the conversions in the question e.g. the answer substitution, addition, elimination, substitution is worth 6 marks.

(c) DESCRIBE:

horizontal test tube with delivery tube connected collection of gas over water //

Bunsen burner for heating / indication of heating //

aluminium oxide / Al₂O₃ / alumina //

ethanol held at end of test tube

[minimum of one label required – no labels deduct 3 marks]

Alternatives: (1) flask with delivery tube to collection over water (3) 160 °C (3)
sulfuric acid (3) in mixture (solution) with ethanol (3)

(2) flask with delivery tube to collection over water (3) 200 °C (3)
phosphoric acid (3) in mixture (solution) with ethanol (3)

HOW: shake with bromine (Br₂) water solution /
shake with acidified (H⁺, H₂SO₄) potassium manganate(VII) (permanganate, KMnO₄, MnO₄⁻)
goes colourless (decolorised) (N.B. not ‘goes clear’) (3)

(c) STATE: reaction requires u.v. light of energy high enough to homolyse chlorine to initiate (start) //
[Allow 6 or 3 for Cl₂ $\xrightarrow{\text{u.v.}}$ 2 Cl⁻ only if it is described as the “initiation (starting) step”]
for every photon absorbed very many (thousands of) molecules of a product are formed //
[Statements such as “each photon produces very many (thousands of) radicals” merits no marks as each photon actually only produces two radicals.]
if irradiation (u.v.) is stopped the reaction slows down (stops) / reaction doesn’t proceed in the dark /
products such as butane / chlorobutane / etc. formed (i.e. alkanes and haloalkanes with a multiple of 2 carbons from C₄ upwards can only be explained by a radical mechanism) //
addition of radical promoters (radical sources, scavengers, tetramethyl lead, tetra-ethyl lead) alter (speed up) the rate of the reaction

ANY THREE: (2 × 6 + 3)
QUESTION 8

(a) DEFINE:

(i) acid: proton (hydrogen ion, \(\text{H}^+\)) donor

(ii) base: proton (hydrogen ion, \(\text{H}^+\)) acceptor

(b) IDENTIFY:

acid (3) its conjugate base (3)

- acid = \(\text{H}_2\text{F}^+\) its conjugate base = \(\text{HF}\)
- acid = \(\text{HCl}\) its conjugate base = \(\text{Cl}^-\)

[If not specified as acid and conjugate base, take the order in the question to be the intended order. Accept if indicated correctly on the equation.]

(c) CALCULATE: \(\frac{3.22}{3.2}\)

\[
\text{pH} = -\log \sqrt{K_a \times M} \quad (3)
\]

\[
\text{pH} = -\log \sqrt{1.8 \times 10^{-4} \times 0.002} / -\log \sqrt{3.6 \times 10^{-7}} / -\log 0.0006 / -\log 6 \times 10^{-4} \quad (3)
\]

\[
\text{pH} = 3.22 \quad (6)
\]

OR

\[
[\text{H}^+]^2 = K_a \times M / 1.8 \times 10^{-4} \times 0.002 / 3.6 \times 10^{-7} \quad (3)^*\]

\[
[\text{H}^+] = \sqrt{1.8 \times 10^{-4} \times 0.002 / \sqrt{3.6 \times 10^{-7}} / 0.0006 / 6 \times 10^{-4}} \quad (3)^*
\]

\[
\text{pH} = 3.22 \quad (6)
\]

*\([\text{H}^+]^2\) and \([\text{H}^+]\) are required in the case of these marks.

(d) BOD: p.p.m. (mg l\(^{-1}\)) (amount) of oxygen consumed
when sample kept in the dark for five days at 20 °C (293 K)

(e) DESCRIBE:

primary: removal of solids (large particles*, floating debris, large items, twigs, etc.) by screening and settlement (sedimentation, grit channels) / physical (accept ‘large dirt’)

secondary: oxidation / breakdown / use of air (oxygen, accept both “aerobic digestion” and “anaerobic digestion”) by micro-organisms (bacteria) / biological / chemical / activated sludge

WHAT:

nitrates (nitrogen compounds)
phosphates (phosphorus compounds)
QUESTION 9

(a) STATE: reactions at equilibrium (2) oppose (Accept 'minimise', 'relieve') applied stress(es)* (3)
*If the word stress(es) is replaced by particular examples (e.g. pressure), all three (temp., pressure & conc.) must be given.

(b) (i) DESCRIBE: choice of methods

Method 1
make solution of (dissolve, put) potassium dichromate in water

\[ \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O} \rightleftharpoons 2\text{CrO}_4^{2-} + 2\text{H}^+ \]

FORMULAS: (3) BALANCING: (3)

Method 2A
make soln of cobalt chloride in hydrochloric acid

\[ \text{CoCl}_4^{2-} + 6\text{H}_2\text{O} \rightleftharpoons \text{Co(H}_2\text{O})_6^{2+} + 4\text{Cl}^- \]

FORMULAS: (3) BALANCING: (3)

Method 2B
make soln of cobalt chloride in water

Method 2C
make soln of cobalt chloride in water and add HCl to intermediate colour (violet, lilac)

Note: the equations may be given in reverse.

(ii) DESCRIBE: choice of methods

Method 1
add sodium hydroxide
the solution changes from orange to yellow

Method 1 (alternative)
Add HCl (no marks)
solution changes from yellow to orange

Method 2A
add water
solution from blue to pink (purple)

Method 2B
add HCl
solution from pink to blue

Method 2C(a)
add water
solution from intermed. to pink (purple)

Method 2C(b)
add HCl
solution from intermed. to blue

(Accept ‘red’ in place of ‘pink’ for Method 2)

[Accept
add sodium hydroxide
monitor pH using a pH meter or pH probe
note increase in pH]

FORMULAS: (3)

(c) (i) WRITE:

\[
\frac{[\text{CH}_3\text{COOC}_2\text{H}_5][\text{H}_2\text{O}]}{[\text{CH}_3\text{COOH}][\text{C}_2\text{H}_5\text{OH}]} \quad \text{(6)}
\]

(ii) CALC:

14.08 – 14.96 g

\[
\begin{align*}
\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} & \rightleftharpoons \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O} \\
0.25 \text{ mol}^* & 0.25 \text{ mol}^* \quad 0 \text{ mol} \quad 0 \text{ mol} \quad \text{(3)} \\
[^* \text{addition must be shown for error to be treated as slip}] \\
0.25 - x & 0.25 - x \quad x \quad x
\end{align*}
\]

\[
\frac{x^2}{(0.25 - x)^2} = 4 \quad \text{(3)}
\]

\[
\frac{x}{0.25 - x} = \frac{2}{3x^2 - 2x + 0.25} = 0 \quad \text{(3)}
\]

\[
x = \frac{1}{6} / 0.16' \quad [\text{allow } 0.16 / 0.17] \quad \text{(3)}
\]

\[
\frac{1}{6} / 0.16' \times 88 = 14.6' \quad (14.08 - 14.96) \quad \text{(3)}
\]

OR

\[
\begin{align*}
\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} & \rightleftharpoons \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O} \\
0.25 \text{ mol}^* & 0.25 \text{ mol}^* \quad 0 \text{ mol} \quad 0 \text{ mol} \quad \text{(3)} \\
[^* \text{addition must be shown for error to be treated as slip}] \\
x & x \quad 0.25 - x \quad 0.25 - x
\end{align*}
\]

\[
\frac{(0.25 - x)^2}{x^2} = 4 \quad \text{(3)}
\]

\[
\frac{0.25 - x}{x} = \frac{2}{3x^2 + 0.5x - 0.0625} = 0 \quad \text{(3)}
\]

\[
0.25 - x = \frac{1}{6} / 0.16' \quad [\text{allow } 0.16 / 0.17] \quad \text{(3)}
\]

\[
\frac{1}{6} / 0.16' \times 88 = 14.6' \quad (14.08 - 14.96) \quad \text{(3)}
\]
QUESTION 10: Answer any two of the parts (a), (b) and (c).

(a) (i) **CALC:** \( \frac{20}{21} \text{ cm}^3 \) \([\text{for answer not given to nearest cm}^3 \text{ or given in litres}]\)  

<table>
<thead>
<tr>
<th>Expression</th>
<th>Solution</th>
</tr>
</thead>
</table>
| \( 2 \times 0.3 \) | \( 0.6 \text{ g} \)
| \( \text{ mol Mg(OH)}_2 \) | \( 0.01 / 0.0103 \text{ mol} \)
| Volume of \( 1.0\text{M HCl} \) | \( 20 / 21 \text{ cm}^3 \)

\( \text{[* addition must be shown for error to be treated as slip]} \)  

(ii) **CALC:** \( 0.95 - 0.99 \text{ g} \) \([\text{correct to second decimal place}]\)  

<table>
<thead>
<tr>
<th>Expression</th>
<th>Solution</th>
</tr>
</thead>
</table>
| \( 0.01 / 0.0103 \text{ mol Mg(OH)}_2 \) | \( 0.01 / 0.0103 \text{ mol MgCl}_2 \)
| \( 0.01 / 0.0103 \text{ mol MgCl}_2 \times 95\% \) | \( 0.95 - 0.98 \text{ g} \)

\( \text{[* addition must be shown for error to be treated as slip]} \)  

(iii) **CALC:** \( 6 \times 10^{21} - 6.21 \times 10^{21} \)  

<table>
<thead>
<tr>
<th>Expression</th>
<th>Solution</th>
</tr>
</thead>
</table>
| \( 0.01 / 0.0103 \text{ mol MgCl}_2 \) | \( 0.01 / 0.0103 \text{ mol Mg}^{2+} \)
| \( 0.01 / 0.0103 \times 6 \times 10^{23} \) | \( 6 \times 10^{21} - 6.21 \times 10^{21} \)

(iv) **HOW:** \( 10 \text{ cm}^3 \)  

<table>
<thead>
<tr>
<th>Expression</th>
<th>Solution</th>
</tr>
</thead>
</table>
| \( 6 \% \text{ (w/v)} \) | \( 6 \text{ g in 100 cm}^3 \)
| => \( 0.6 \text{ g in 10 cm}^3 \) |

(b) (i) **IDENTIFY:** first ionisation energy / first ionisation potential [Allow 3 marks for ionisation energy (potential)]  

**STATE:** kilojoules per mole (kJ mol\(^{-1}\)) / joules per mole (J mol\(^{-1}\)) / electron volt(s) (eV)  

(ii) **EQUATION:**  
\[ \text{X}(g) \rightarrow \text{X}^+ (g) + e^- / \text{X}(g) - e^- \rightarrow \text{X}^+ (g) \]  
[Allow (3) for equation given without state symbols]  

(iii) **WOULD:** less  

**EXPLAIN:** already gained energy (partially removed) / already raised to higher level / already excited / further from nucleus  
[The (3) for EXPLAIN cannot be awarded if the answer to WOULD is incorrect]  

(iv) **HOW:** very / quite / fairly / reactive  

**REACT:** by losing electron(s) / oxidised / becoming positively charged  

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Question 10 continued/

(c) **STATE:** separation of a mixture of components

**based on their** selective adsorbance on / based on their relative affinities (attractions) for / based on their partitioning between / based on their different interactions with // a stationary phase // and a mobile phase / while carried by a mobile phase

[There can be no suggestion that the components react chemically with either the mobile or stationary phases]

**DESCRIBE:** Three methods:

- Paper Chromatography
- Thin-layer chromatography
- Column chromatography

<table>
<thead>
<tr>
<th>Paper Chromatography</th>
<th>Thin-layer chromatography</th>
<th>Column chromatography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply mixture using dropper (capillary tube) / spotting on paper //</td>
<td>Apply mixture using dropper (capillary tube) / spotting on plate //</td>
<td>Dissolve mixture in solvent (eluent*) / apply mixture to top of column //</td>
</tr>
<tr>
<td>About 2 cm above bottom of sheet / just above eluent (or from top – see below) //</td>
<td>About 2 cm above bottom of plate / just above eluent //</td>
<td>Add to top of column / add solvent to top of column //</td>
</tr>
<tr>
<td>Place in eluent* (solvent, mobile phase) in tank (sample above solvent) //</td>
<td>Place in eluent* (solvent, mobile phase) in tank (sample above solvent) //</td>
<td>Continue to add eluent (solvent, mobile phase) so that it flows down through column //</td>
</tr>
<tr>
<td>Elute (solvent moves up – or down – see below) //</td>
<td>Elute (solvent moves up) //</td>
<td>Separation occurs / bands shown //</td>
</tr>
<tr>
<td>State or show separation of components of mixture</td>
<td>State or show separation of components of mixture</td>
<td>Collect different components / show separation into bands</td>
</tr>
<tr>
<td>*Accept named eluent</td>
<td>*Accept named eluent</td>
<td>*Accept named eluent</td>
</tr>
</tbody>
</table>

*All (5 x 3) written or through a labelled diagram or diagrams (See N.B. below.)*

**Note 1:** The elution stage (point 4 above) must be clearly cited, either by a statement to that effect, or by clearly shown (labelled) solvent fronts in the case of paper or thin-layer chromatography.

**Note 2:** in paper chromatography, the solvent may be at the top of the tank with the mobile phase moving down.

**N.B.** no diagram – or diagram not having at least one label – : deduct 3, if at least 3 marks have been awarded.
QUESTION 11: Answer any two of the parts (a), (b) and (c).

(a) (i) DEFINE: increase in oxidation number (4)

(ii) WHAT: solution turns red-brown (red, orange, yellow) (3)

EXPLAIN: bromide ions oxidised to bromine / Br→ Br₂ / Br(-1) to Br(0) (3)

chlorine reduced to chloride ions / Cl₂ → Cl⁻ / Cl(0) to Cl(-1) (3)

[NaBr & NaCl can replace Br⁻ & Cl⁻ respectively]

[All 6 marks can be got for a single complete equation representing what happens]

(iii) ELECTRODE: A / anode / positive electrode (3)

WHICH: H₂O (water) (3)

WRITE: H₂O → ½O₂ + 2H⁺ + 2e⁻ / 2H₂O → O₂ + 4H⁺ + 4e⁻ / 3H₂O → ½O₂ + 2H₃O⁺ + 2e⁻ / 6H₂O → O₂ + 4H₃O⁺ + 4e⁻ / H₂O – 2e⁻ → ½O₂ + 2H⁺ / 2H₂O – 4e⁻ → O₂ + 4H⁺ / 3H₂O – 2e⁻ → ½O₂ + 2H₃O⁺ / 6H₂O – 4e⁻ → O₂ + 4H₃O⁺

FORMULAS: (3) BALANCING: (3)

[Allow 3 marks for a balanced equation representing the oxidation of hydroxide ion]

(b) (i) DEFINE: has as many (same number of) particles* as 12 g (0.012 kg) of carbon-12 / contains the Avogadro number (Avogadro constant, L, 6 x 10²⁳) of particles* / the relative formula mass (molecular mass) in grams (g) (7)

[Accept “atoms”, “ions” or “molecules” in place of “particles”]

(ii) STATE: equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles) under same conditions of temperature and pressure (Do not accept "at s.t.p.") (3)

[Allow 3 marks for “one mole of a gas at s.t.p. occupies 22.4 litres”]

(iii) HOW MANY: 2.4 x 10²² – 2.5 x 10²² atoms (12)

10 % (v/v) = 10 cm³ per 100 cm³ / 10 litres per 100 litres (3)

=> volume of helium = 1 litre (3)

= 1/24 mol / 0.0416 mol (3)

x 6 x 10²³ = 2.4 x 10²² – 2.5 x 10²² atoms (3)
Question 11 continued/

(c) Answer either part A or part B

A

(i) WHAT: monomers (small molecules) combining (linking, joining) to form a polymer (large molecule, giant molecule, big molecule) (4 + 3)

(ii) NAME: Plunkett (3)

(iii) DESCRIBE: nCF$_2$CF$_2$ → (−CF$_2$CF$_2$−)$_n$ // nCF$_2$CF$_2$ → (−CF$_2$−)$_{2n}$ (9)

[Allow 3 marks for the correct formula for CF$_2$CF$_2$; 3 marks for 2 or more repeating units; and 3 marks for a multiple i.e. “n”]

[If expanded structure of CF$_2$CF$_2$ is given then the double bond must be shown; no end dashes in (−CF$_2$CF$_2$−)$_n$ or (−CF$_2$−)$_{2n}$ - lose 3 marks; incorrect “n” – lose 3 marks] [Accept C$_2$F$_4$ for CF$_2$CF$_2$]

(iv) GIVE: medical body parts (qualified) e.g. blood vessels, joints, corneas, tracheas) // dental work (qualified) // stain resistance on fabrics and wood (qualified) (e.g. carpets, curtains, clothes, floors) // non-stick surfaces // plumbing tape // paints // windscreen wipers // lubricants // burette taps ANY TWO: (2 × 3)

B

(i) ACCOUNT: high bond energy (strong / difficult to break) // non-polar // triple bond ANY TWO: (4 + 3)

(ii) WHAT: conversion of atmospheric nitrogen to nitrogen compounds that can be used (useful compounds, chemically reactive) (3)

STATE: electrical storms (lightning) // legumes (Rhizobium) (named legume) // alder (Plasmodiophorales) // nitrogen fixing bacteria (Azotobacter, Clostridium, Krebsiella) // blue-green algae (Cyanophyceae, Anabaena) // photosynthetic bacteria (2 × 3)

(iii) DESCRIBE: spark plug (electrical discharge) / high temperature / compression (high pressure) in the ignition system provides the energy for (allow facilitates) the first reaction (3)

\[ N_2 + O_2 \rightarrow 2NO \quad \text{or} \quad \frac{1}{2}N_2 + \frac{1}{2}O_2 \rightarrow NO \] (3)

\[ NO + \frac{1}{2}O_2 \rightarrow NO_2 \quad \text{or} \quad 2NO + O_2 \rightarrow 2NO_2 \] (3)

[Allow 6 marks for the combined equation \( N_2 + 2O_2 \rightarrow 2NO_2 \) or \( \frac{1}{2}N_2 + O_2 \rightarrow NO_2 \) but no marks unless fully correct and balanced]